reprinted. This volume is an essential reference tool for anyone interested in the history of medieval mathematics, as well as for the history of the history of mathematics.

Antoni Malet
Universitat Pompeu Fabra,
Departament d'Humanitats,
c. Ramon Trias Fargas 25,
08005 Barcelona, Spain
E-mail address: antoni.malet@upf.edu

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Pensions and Insurance before 1800: A Social History
By Christopher G. Lewin. East Lothian, Scotland (Tuckwell Press). 2003. ISBN 1-86232-211-2. xvi + 471 pp. £25

Mathematics is a relatively inexpensive scientific enterprise. Some say it requires only pencils and coffee. Still, it has its costs. Since the mathematics community cannot sustain itself on the things it produces, the discipline survives only when others are willing to pay for it. A historian of mathematics could use a "Watergate" style investigative strategy and "follow the money": see who pays for mathematics and why. That historian would find Pharaoh's surveyors funding Egyptian geometry, European navigators financing much of the 18th century, astronomers backing medieval Arabic, Hindu, and Chinese mathematics, and merchants and consumers paying for mathematics everywhere and always. Christopher Lewin has written a book that illuminates this last sponsor of mathematics, the world of commerce.

Christopher G. Lewin enjoyed a career as a pensions manager. Papers from his time on the British Railways Board are in the National Archives. He has published articles on the history of actuarial science (e.g., Lewin, 1970) that are much like many papers on the history of mathematics. He has added to these a history of the pensions and insurance industries. His treatment gives special emphasis to the mathematics and mathematicians that the financial services industries have supported over the centuries. His accounts are flavored with his own experiences and his audience is clearly expected to be other actuaries and pension managers. Historians of mathematics are welcome, but we are not the primary audience.

There are a number of very familiar mathematical names, Simon Stevin, Blaise Pascal, Colin Maclaurin, Edmund Halley, Thomas Simpson, and some less familiar ones, such as Francis Maseres, Francis van Schooten, and Jan de Witt. There are people better known for their achievements outside mathematics, Geoffrey Chaucer and Sir Walter Raleigh, and names apparently well known among actuaries, but little heard among mathematicians, Richard Witt and John Graunt.

Lewin follows the tried and true recipe for topical histories and begins with several surviving accounts of insurance-like and pension-like transactions from Biblical times and ancient Greece and Rome. At the time, and even through most of the Renaissance, insurance usually took the form of a kind of high-interest loan on a ship and its goods that did not have to be repaid if the cargo did not arrive safely at its destination. Pensions were rare, and the ones we know about were mostly organized as veterans' societies for those Roman soldiers lucky enough to survive 30 years of service and reach the retirement age of 46. For most of the ancient era, evidence is sparse and so it is difficult to forge a cohesive narrative thread. The account of ancient insurance and pensions is more like a collection of stories and vignettes than a history.

The historical record becomes richer, and the story more cohesive, as we move through the Middle Ages and into the Renaissance. We see a gradual development of financial centers around Europe and the evolution of commercial law and systems of monetary exchange. Governments enforced usury laws, capping interest rates, and different financial centers competed for banking and insurance business. Lewin documents a good deal of this, providing a great amount of data and many anecdotes.

One story seems almost worthy of Weierstrass as a "pathological example" of the twists that can occur as an insurance contract unfolds. The story comes from the *Lex Mercatoria* [Malves, 1620] of Gerard Malves, a 17th-century textbook on commercial law. He describes a ship, the *St. Peter*, insured in Antwerp for a voyage from the East Indies to London. The ship failed to arrive when expected, but three years later, a smaller ship arrived carrying some of the goods from the *St. Peter*. It seems that the ship had been cast aground on an island, and the crew had salvaged the original ship to build the new one and to deliver what goods they could. No insurance policy could have anticipated such an event. A court eventually gave the ship to the original owners and divided the value of the goods between the insurers and the crew.

Through the Renaissance, pensions were rare. Most people either worked until they died, or saved their own retirement funds. Some, such as tax collectors, judges, and certain clergy, could sell their positions in exchange for a life annuity from the new tenant. Sometimes monarchs would reward faithful service with a pension, usually in the form of room and board and a small allowance at a monastery or convent. In general, though, pensions were slow to evolve, in part because, apart from the Church and the monarchy, there were few institutions likely to outlive one or more of the parties involved.

Several such institutions began to form in the 17th and 18th centuries, including organizations such as the East India Company, the Hudson Bay Company, and any number of guild societies and companies. When these institutions started writing insurance and pension contracts, the ad hoc methods of calculation for premiums and payoffs that had been in use were no longer sufficient. New mathematics and methods of calculation were developed, and Lewin begins the part of his story that will most interest historians of mathematics.

In 1495 the English Parliament passed a law banning the lending of money at interest, on the ground that the Bible denounces usury. In fact, the word "interest" was not used until much later; all interest was usury. In 1545, another law was passed, repealing the act of 1495 and setting the maximum rate of usury at 10%. Lending at interest was prohibited again in 1552, but allowed again, still at 10%, in 1571. Over the next 200 years, legal interest rates were gradually cut to 6%. There were other constraints as well; for example, "The borrower's gain must be so much more at least as the usurer's interest come unto" (p. 129). Compound interest was supposedly illegal. Of course, throughout the period, illegal loans at interest were available, and those with the means to travel could borrow at interest on the Continent. There were often similar laws elsewhere in Europe, but apparently loans at interest were always legal and available somewhere.

Starting in 1571, the interest ceiling in England was enforced with some vigor. For all but the simplest contracts, people had to learn how to calculate whether or not a given transaction charged interest in excess of 10%. Mathematicians responded with textbooks describing how to make the necessary calculations. One of the first was in 1585 by Simon Stevin, of decimal numbers fame. A clue that the strictures against compound interest were not as well enforced as the interest rate rules is that Stevin's book includes compound interest and amortization tables up to 30 years.

In 1613, Richard Witt published the first substantial book dealing only with compound interest. Lewin wrote a 1970 article on Witt's book in which he writes, "it is doubtful whether many actuaries have previously been aware of its existence" [Lewin, 1970, 121]. By 2003 he is able to call it "a landmark in the history of compound interest" (p. 140). Lewin's article [1970] is probably responsible for the improvement in Witt's status. Lewin describes Witt's book in some detail, reproducing several pages of text and examples. He also gives us a generous bibliography of the literature of mercantile mathematics of the time. Many of the names and works are familiar, Briggs, Napier, Hutton, and Recorde, but there are several lesser-known works by Harriot, Stevin, and Locke, and many hard-to-find works by mostly obscure authors.

In the 17th century, life expectancies were gradually increasing, and established traditions in lifetime contracts were becoming obsolete. For example, it was common for a person or a couple to take a lifetime lease on a piece of property for some fixed sum payable at the beginning of the lease (though they could apparently borrow to raise that sum). The amount of the lease was based on the expected annual revenue from the property, and not on the ages of the tenants. A typical rate would be seven years' revenues. This worked fine when most people died of accident or illness, and an average adult could expect to live another ten or twelve years, regardless of age. As people started to live longer, this stopped working so well.

At about the same time, governments began selling pensions to raise money as an alternative to taxation, and both companies and societies were founded to sell pensions. The printers at Oxford University set up a life assurance scheme in 1707. They collected one shilling each week from each subscriber, plus an additional shilling three times

a year, at Christmas, Easter, and Wakegoose. Lewin doesn't tell us when Wakegoose was.[1] A lump sum was paid on a member's death, depending on how long he had been a member, growing from just over a pound after one year to £44 after 22 years.

The administrators of such schemes soon realized that the viability of their products depended on a good understanding of life tables, and mathematicians again stepped forward. The names best known among actuaries seem to be John Graunt and Sir William Petty, with supporting roles played by people like Christian Huygens, Colin Maclaurin, and Leonhard Euler. By the close of Lewin's book around 1800, actuarial science is almost grown up and clearly resembles today's profession.

Overall, Lewin has written a good book on the history of pensions and insurance. It is written for an audience of actuaries, and has enjoyed a number of glowing reviews in the actuarial literature. It is generally well written and is pleasant to read. Lewin is not a historian, nor a mathematician, and not a historian of mathematics. His book is not a work of historical scholarship, and we should not judge it as such. Nor is he like a veteran of some Victorian war, writing his reminiscences. He is a retired actuary, well liked and highly respected in his field. To historians of mathematics he is like a "fellow of another college," writing a popular history of one of our sister professions. He has given us copious references and lots of loose ends. His story of early modern mercantile mathematics is particularly interesting. It reminds us that mathematics is inspired and nourished by business, as well as by its more traditional sponsors in science, engineering, astronomy, and the military. We should hope that someone uses his work as a starting point for a history of this largely neglected subject.

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C. Edward Sandifer
Department of Mathematics,
Western Connecticut State University,
Danbury, CT 06810, USA
E-mail address: esandifer@earthlink.net

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Lenses and Waves. Christiaan Huygens and the Mathematical Science of Optics in the Seventeenth Century
By Fokko Jan Dijksterhuis. Archimedes. New Studies in the History and Philosophy of Science and Technology, vol. 9. Dordrecht (Kluwer Academic). 2004. ISBN 1-4020-2697-8 (also available as e-book). 289 pp. $109

During his lifetime, Christiaan Huygens was widely recognized as one of the "lions" of the "Republic of the Sciences." As has often been pointed out, however, he displayed few of the flamboyant traits and/or universalist tendencies that were so characteristic of many of his fellow "greats." Differently from his sometime rival Newton, Huygens showed little interest in natural philosophy, or in any form of speculation for that matter. His interests were almost uniquely limited to mathematics itself and those parts of the sciences that were directly amenable to mathematical treatment. Even in his mathematical work, in sharp contrast to Descartes, Huygens was much more interested in solving concrete problems with time-honored tools than creating new techniques. A diplomat by inclination, he was more interested in working within the conventions of the sciences of the 17th century than in forging new ones.

[1] Traditionally, Wakegoose was a banquet given by a printer for his employees around August 24 to mark the beginning of the season of working by candlelight.